Foreword

National
Oceanic and
Atmospheric
Administration

U.S.
DEPARTMENT
OF
COMMERCE

NOAA Fisheries Service
Northeast Cooperative Research Partners Program

The National Marine Fisheries Service (NOAA Fisheries Service), Northeast Cooperative Research Partners Program (NCRPP) was initiated in 1999. The goals of this program are to enhance the data upon which fishery management decisions are made as well as to improve communication and collaboration among commercial fishery participants, scientists and fishery managers. NOAA Fisheries Service works in close collaboration with the New England Fishery Management Council's Research Steering Committee to set research priorities to meet management information needs.

Fishery management is, by nature, a multiple year endeavor which requires a time series of fishery dependent and independent information. Additionally, there are needs for immediate short-term biological, oceanographic, social, economic and habitat information to help resolve fishery management issues. Thus, the program established two avenues to pursue cooperative research through longer and short-term projects. First, short-term research projects are funded annually through competitive contracts. Second, three longer-term collaborative research projects were developed. These projects include: 1) a pilot study fleet (fishery dependent data); 2) a pilot industry based survey (fishery independent data); and 3) groundfish tagging (stock structure, movements and mixing, and biological data).

> First, a number of short-term research projects have been developed to work primarily on commercial fishing gear modifications, improve selectivity of catch on directed species, reduce bycatch, and study habitat reactions to mobile and fixed fishing gear.
>
> Second, two cooperative research fleets have been established to collect detailed fishery dependent and independent information from commercial fishing vessels. The original concept, developed by the Canadians, referred to these as "sentinel fleets". In the New England groundfish setting it is more appropriate to consider two industry research fleets. A pilot industry-based survey fleet (fishery independent) and a pilot commercial study fleet (fishery dependent) have been developed.
>
> Additionally, extensive tagging programs are being conducted on a number of groundfish species to collect information on migrations and movements of fish, identify localized or subregional stocks, and collect biological and demographic information on these species.

For further information on the Cooperative Research Partners Programs please contact:

National Marine Fisheries Service (NOAA Fisheries Service)
Northeast Cooperative Research Partners Program

(978) 281-9276 – Northeast Regional Office of Cooperative Research
(401) 782-3323 – Northeast Fisheries Science Center, Cooperative Research Office, Narragansett Laboratory

www.nero.noaa.gov/StateFedOff/coopresearch/

Final Report

A High-Resolution, Industry-Conducted, Fishery Resource Survey

A Cooperative Project Involving
The School for Marine Science and Technology/University of Massachusetts Dartmouth; Massachusetts Fisheries Recovery Commission; Trawler Survival Fund; and Massachusetts Division of Marine Fisheries

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A. EXECUTIVE SUMMARY

In October 2000, NOAA’s National Marine Fisheries Service funded a partnership of the New Bedford area Trawler Survival Fund (TSF), the School for Marine Science and Technology (SMAST) of the University of Massachusetts Dartmouth, the Massachusetts Fisheries Recovery Commission (MFRC), and the Massachusetts Division of Marine Fisheries (MDMF) to undertake a high-resolution, industry-conducted survey of the regional ground fisheries. The fishing vessels involved in this project operate simultaneously as commercial fishing vessels and as research platforms. Crews on twenty TSF groundfish vessels, trained by SMAST staff, logged both fisheries and environmental data on standard log sheets that are compatible with NMFS logs. A water profile data acquisition system was employed that consists of (1) inexpensive temperature probes attached to each net and (2) a prototype water conductivity(salinity) / temperature / depth (CTD) profiling system.

Between December 2000 and October 2001, twenty different TSF trawlers spent 949 days at sea on 119 fishing/survey trips. During this period, they conducted 4,508 separate hauls for an average of 4.8 trawls per at-sea day (or 6.3 trawls per fishing day).

A total of 67 different fish species were caught and inventoried, with the five most important commercial species being codfish, monkfish, witch flounder, American plaice flounder, and haddock. Codfish, the usual target species, were caught on 2,731 trawls (84% of the hauls) for a total of 636 x 10^3 lb (224 lb/haul) and an average catch per unit effort (CPUE, related to fish abundance) of 1.63 lb/minute. The best times to fish for codfish are early spring and mid-summer. Monkfish were caught on 2,746 trawls (82%) for a total of 720 x 10^3 lb (221 lb/haul) and an average CPUE of 1.20 lb/minute. Monkfish were most often caught during late summer or spring. Witch flounder were caught on 1,871 trawls (53%) for a total of 188 x 10^3 lb 98 lb/haul) and an average CPUE of 0.49 lb/minute. The witch flounder fishery is relatively constant throughout the year. Plaice were caught on 1,780 trawls (50%) for a total of 223 x 10^3 lb (124 lb/haul) and an average CPUE of 0.63 lb/minute. Plaice were most often caught during the summer months. Haddock were caught on 1,566 trawls (45%) for a total of 330 x 10^3 lb (195 lb/haul) and an average CPUE of 1.42 lb/minute. Haddock were caught during mid-winter to spring and mid-summer.

In mid-July 2001, we began assimilating Trawl Survey bottom temperature data into our weekly RFAC/AFMIS model runs. In the first trial, the June 1-15 2001 bottom temperatures were used to initialize the bottom temperature field of the Gulf of Maine RFAC/AFMIS domain model calculation. These model nowcast and forecast temperature fields are directly involved in our fish migration modeling that is just getting underway. The fish models will be initialized by the Trawl Survey fish observations.

These temperature data, along with bottom depths and logged bottom types were used to assess fish environmental preferences. According to log entries of fish caught and CPUE data, most species preferred a temperature range of 5-7°C. Highest CPUEs were usually found in the 4-5°C range. The five species mentioned above were most often caught between depths of 150-190m (with a second significant range of 50-70m for codfish).

B. INTRODUCTION

In October 2000, NOAA’s National Marine Fisheries Service funded a partnership of the New Bedford area Trawler Survival Fund (TSF), the School for Marine Science and Technology (SMAST), the Massachusetts Fisheries Recovery Commission (MFRC), and the Massachusetts Division of Marine Fisheries (MDMF) to undertake a high-resolution, industry-conducted survey of the regional ground fisheries. The TSF represents fifty groundfish trawler owners and captains with homeports in or near New Bedford, Massachusetts.

In this project, twenty of the TSF fishing vessels operated both as commercial fishing vessels and as research platforms to obtain fisheries data and environmental information. The approach was to train crewmembers on each of a fleet of volunteer TSF groundfish vessels to obtain detailed field data in the course of their normal fishing activities (for nominal compensation of $300/day). During the ten months of the project, crewmembers on twenty TSF vessels (Appendix A) underwent training and collected fisheries and environmental data.

This approach enabled us to obtain uniquely high time/space-resolution data on the multi-species fish distributions at commercially fished sites. These study results complement those of the semiannual NMFS surveys. We were also able to tag some fish as part of another MFRC-funded SMAST program. The data from these daily, highly resolved, industry-based survey are leading to (1) better understanding of the high CPUE variability and (2) improved estimates of stock abundances. The CPUE estimates are being examined in terms of actual and relative catchability coefficients (e.g., fishing power) for a selection of target and bycatch species. This information can be statistically related to different types of vessels, fishing gear, fishing ground locations and properties, time of day, fishing practices, etc.

A notable achievement of this project was that the crew members on the fishing vessels and SMAST researchers were able to work together to collect a set of unique scientific fisheries and environmental data in the context of routine fishing operations. The data from individual vessel trips/trawls is proprietary and thus confidential. In fact, some TSF fishermen have found the data that they collected useful to their own operations. However, the objectives of this partnership promise an even greater benefit to both the fishermen and the researchers as we develop a much better understanding of the short-term and fine-scale variability of the multi-species ground fishery.

Those project objectives are:

- to measure gear- and vessel-specific catch per unit effort (CPUE);
- to use high-resolution data collected by the fleet to spatially resolve fishery management models;
- to map relative fish distributions, both target and bycatch, by species;
- to map environmental data structure (three-dimensional temperature);
- to link environmental data collection with operational catch information; and
- to demonstrate the feasibility of a cooperative project between the fishing fleet and scientists.

C. METHODS

1. At Sea Data Acquisition

Between November 2000 and September 2001, a group of New Bedford area Trawler Survival Fund (TSF) bottom fishers and School for Marine Science and Technology (SMAST – UMass Dartmouth) scientific researchers collected and archived fish catch and environmental data obtained during normal commercial fishing activities. Dr. Frank Bub, the SMAST project manager worked directly with Mr. Robert Lane, who is a fisherman and TSF vessel owner, to coordinate project activities between the fleet and SMAST. During the project, 20 TSF vessels collected data from 4,508 net hauls made during 721 days on 119 separate fishing trips. (See Appendix A for project participants and contributions).

The TSF vessel captains and vessel crew (usually 5) was responsible for collecting the data during routine fishing operations. About half the participating TSF vessel crew were Portuguese-speaking fishermen of Azores and Cape Verde Islands heritage. These crewmembers are initially trained to collect the data by SMAST At-Sea Technicians, who taught sampling techniques and log keeping. The Technicians conducted additional training and received additional feedback on the quality of data collected. The vessel captains oversaw the data-logging activities by the crew, and were important participants in the data collection effort.

The TSF vessels are 75-100 foot groundfish trawlers. To participate it this project, vessels were expected to meet all Coast Guard safety regulations. These vessels operated under a standard commercial fishing regime, in which they followed all normal regulations and received no special research permits. The captains choose the methods, gear, location, and time of each trawl, based on their personal knowledge and commercial considerations. Fishing trips normally lasted between five and twelve days (average 8.3 days). The individual net trawls were one to five hours long at speeds of two to three knots, depending on the captain's techniques, time of year, catch rate, and target species. Fishing gear was standard square- and diamond-rigged mesh nets spread across the bottom by a pair of otter boards. Fish were collected in a cod end, hauled in, and sorted on deck. For this project, the vessels are paid $300/day to collect the required data.

The trawl data were recorded on log sheets and by electronic temperature sensors. Over the course of the project, SMAST and the TSF crews developed a set of log sheets on which were recorded information similar to that of the NMFS observer program (Appendix B). These data logging protocols were designed to be efficient and assure that the data could be integrated with NMFS databases.

The data that were logged include:

- Vessel and gear characteristics;
- Trip summaries;
- Fish composition of each trawl in terms of species, weight, and disposition;
- Tow duration, direction, speed, wire used;
- Environmental factors, including location, depth, weather, and bottom types; and
- Length-frequencies of the important species such as cod, haddock, and various flounders (see Appendix B for a full listing of log entries).

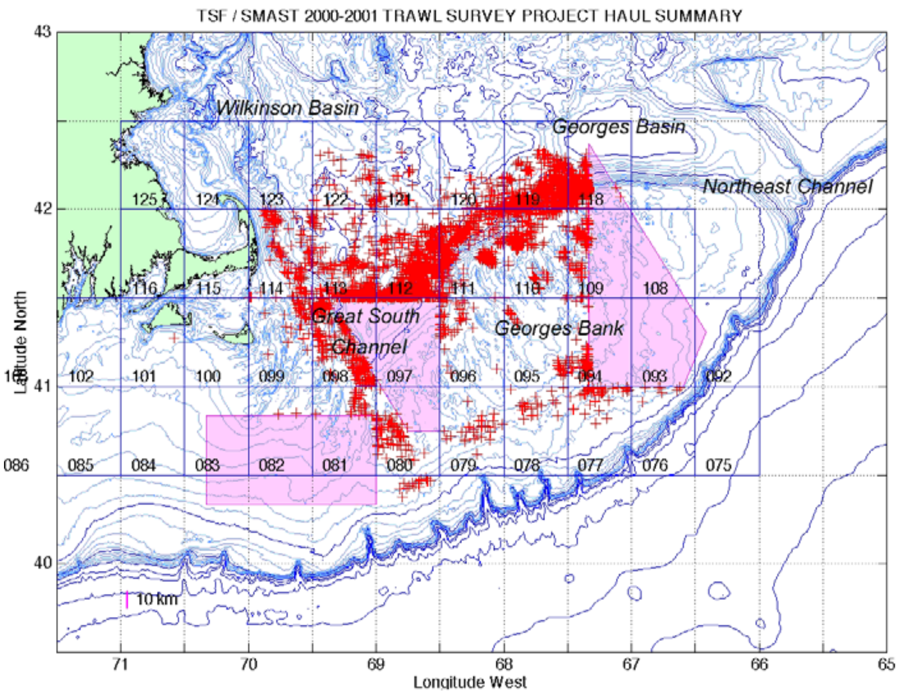

Figure 1. Summary of Trawl Project haul locations. Gear restriction areas are shaded. Numbers identify NMFS Statistical Areas.

The New Bedford bottom trawler fleet fishes in the Georges Bank area south of latitude 42.5°N. Figure 1 shows the total distribution of net hauls recorded during the 2000-2001 period. Table 1 summarizes the hauls by NMFS statistical area. Note that the most hauls occurred in Area 112, followed by 119, 118, 111, 113, and 110. The cumulative summary of hauls collected during each 10-day period is shown in Table 1 and Figure 2. Figure 3 illustrates a month-by-month distribution of these hauls.

Table 1. Distribution of Project Haul Data collected by NMFS Half-Degree Square Statistical Areas.

STATISTICAL AREA	**75**	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**
HAULS	0	7	44	23	29	103	36	2	0	0	0
STATISTICAL AREA	**86**	**92**	**93**	**94**	**95**	**96**	**97**	*** 98**	**99**	**100**	**101**
HAULS	0	0	0	68	30	58	2	259	53	0	1
STATISTICAL AREA	**102**	**103**	**108**	**109**	*** 110**	**** 111**	****** 112**	*** 113**	**114**	**115**	**116**

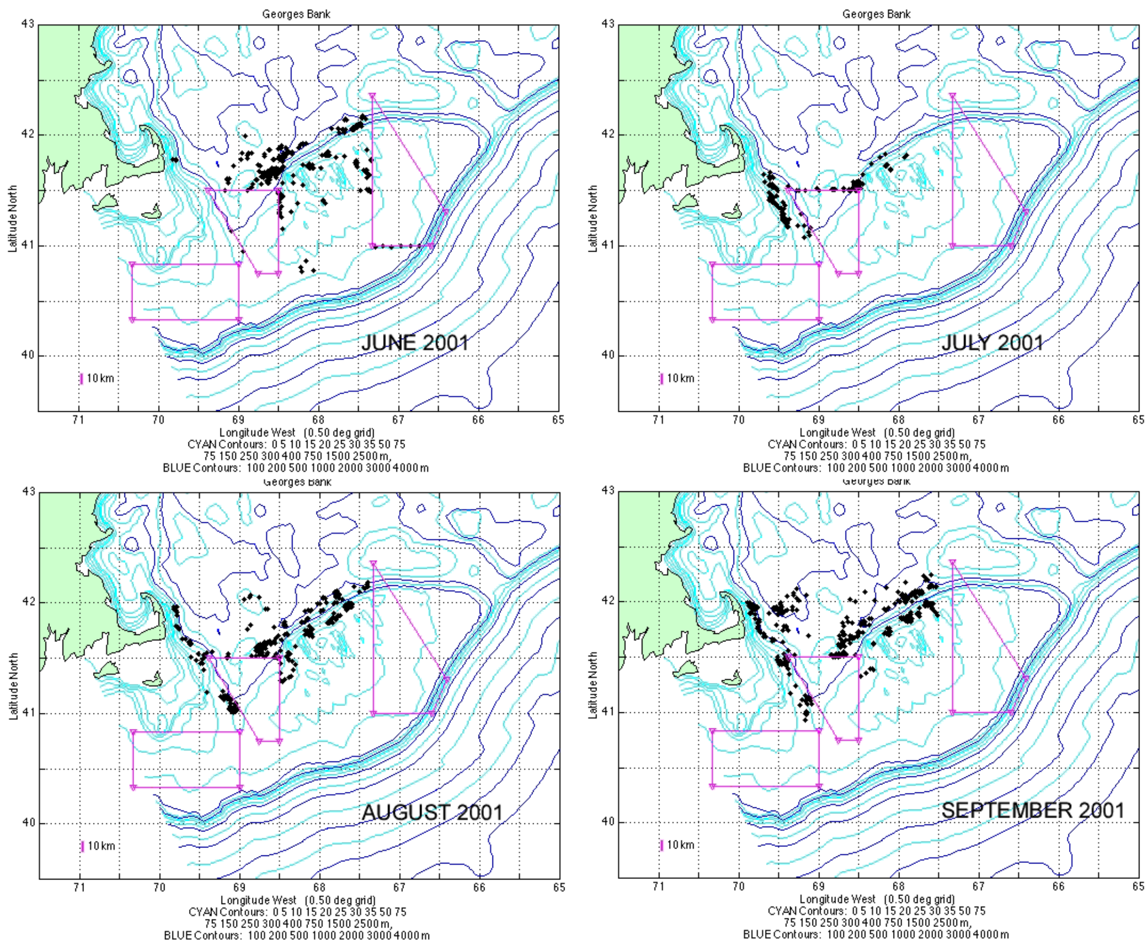

Figure 3. Monthly summaries of haul locations (black dots). Gear restriction areas are outlined.

2. Fisheries Data Collection

The project fishermen logged fish catch data and information from 3,975 hauls on 111 trips (see Appendix C). When data were not collected, it was usually during late night hauls, periods of rough seas, or particularly busy days. There are a total of 26,009 individual fish data entries (i.e., species, weight kept, weight discarded, and discard reason). On average 6.5 different species were logged on each haul.

Table 3. The 'top 10' species by log entry counts and weights.

RANK	BY ENTRIES MADE	COUNT	BY TOTAL WEIGHT	POUNDS
1	Monkfish (tail+whole)	2,748	Skate (all species)	1,253,347
2	Codfish	2,731	Codfish	635,525
3	Skate (all species)	2,442	Monkfish (tail+whole)	720,477
4	Witch Flounder	1,871	Haddock	329,536
5	Am. Plaice Flounder	1,780	Yellowtail Flounder	314,759
6	Am. Lobster	1,706	Winter Flounder	277,468
7	Haddock	1,566	Witch Flounder	188,348
8	Yellowtail Flounder	975	Dogfish (all species)	134,092
9	Winter Flounder	935	Am. Lobster	80,833
10	Pollock	808	Pollock	69,570

During the 111 trips when data was obtained, 67 separate species were identified (Appendix C). Of those, there were over 100 log entries for 26 of the species; for 24 species more than 10,000 pounds were logged. Table 3 summarizes the "top 10" species in terms of log entries and total weight recorded.

There were a total of 11,008 length-frequency measurements made on 822 (18%) hauls during 72 of the trips. Crews were asked to make these measurements when they had time and there were at least 25 fish of a species available. Figure 4 summarizes the distribution of 8,125 length-frequency measurements for five important species: codfish (1,682 samples), haddock (520), yellowtail flounder (2,284), witch flounder (1,777), and winter flounder (1,862) (comprising 69 trips and 674 hauls). These hauls are located on Figure 4.a.

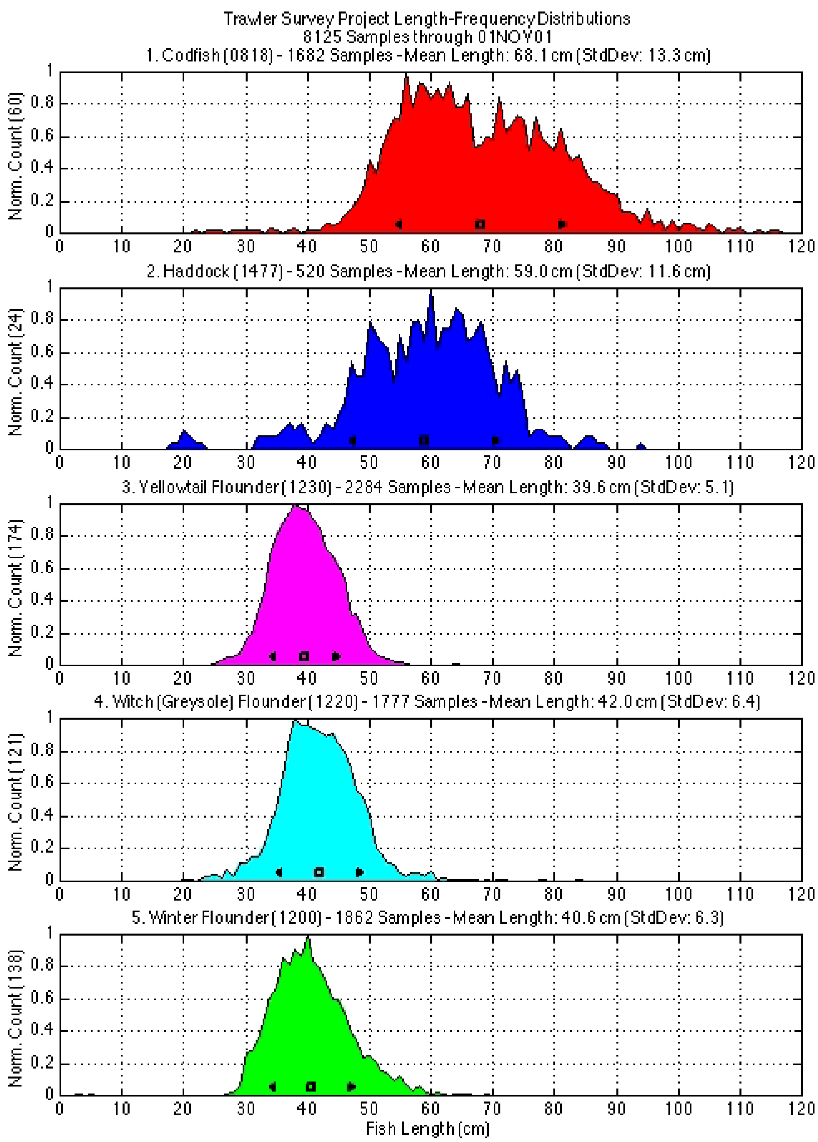

Figure 4. Trawl Project summaries of length-frequency distribution plots for (top to bottom) codfish, haddock, yellowtail, witch and winter flounder. Mean (square) and one standard deviation values (triangles) are indicated.

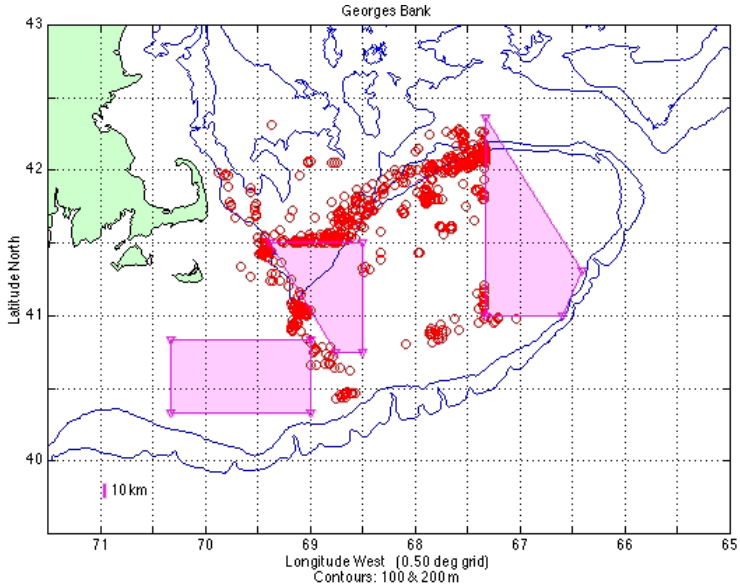

Figure 4a. Location map of length-frequency data.

3. Environmental Data Collection

Electronic temperature sensors were attached to each vessel's fishing gear and they recorded temperatures at one-minute intervals during the whole trip. Relatively inexpensive ($90) ***Onset Tidbit*** time-temperature data loggers (Figure 5) were used. These sensors were started at SMAST and attached to the net gear by the crew at the beginning of every trip. Ocean bottom temperature and time entries were recorded at one-minute intervals during the trip (Figure 6). The manufacturer-provided uncertainty is about ±0.2° C. The relatively slow instrument response time (***Onset*** specifies 3 minutes to 90% step change in water), precluded making water column temperature profile measurements. Although the ***Tidbits*** are tough, we lost or broken a few, and continued to experimented with mounting and protection methods.

After each fishing trip, the ***Tidbit*** temperature time series records were uploaded to a desktop computer, geographically located using the log data, and then archived. Due to the logistics and data processing time, there is a two- to ten-day delay between the actual temperature measurement and its archived form.

Figure 5. The ***Onset Tidbit*** temperature probe. Size is about 1.25 inches in diameter by 0.75 inches thick. Sensors are protected by nylon bait bag material and secured to fishing gear using tie-wraps.

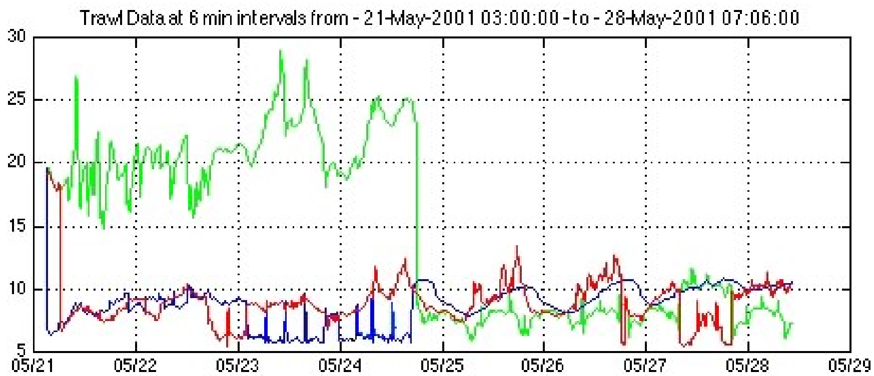

Figure 6. ***Tidbit*** temperature time series for the 3 different probes (A - red, B -blue, and C -green) that were attached to nets during trip 082. Bottom water temperature varied between 5 and 10°C, depending on location. ***Tidbits*** A & B measured bottom temperatures until 05/24. The spikes in these records show the times when the net was brought to the surface between hauls. Note that when the trip started, ***Tidbit*** C was in the wheelhouse and measured air temperatures that ranged from 15 to 25°C. Thereafter ***Tidbits*** C and A were used.

4. Data Quality Control and Archiving Procedures

Collection: When a TSF vessel captain scheduled a fishing trip, SMAST assembled a package that included a full set of the five different log sheets, an Observer Manual, a Common Fish Identification handout, and two (or three) activated ***Tidbit*** temperature sensors (Appendix B and Figure 7). The ***Tidbits*** were started on the day of the trip and set to log temperature data at one-minute intervals. A SMAST at-sea technician or the TSF representative delivered the packages and reviewed procedures with the captain and crewmember observers. The ***Tidbits*** were attached to each trawl net with mesh nylon bait bag material and tie-wraps, and remained in place during the trip. It is estimated that the water temperatures were being measured at approximately three meters above the bottom during each trawl.

During the at-sea operations, the captain recorded the times, positions, bottom and gear depths, bottom type, sea and weather data, etc. for each haul's start, turn(s), and end in the *Environmental Data Position Log*. The contents of each log are summarized in Appendix B. After each net was hauled and emptied, the crew observer recorded all the weight of all species caught (both kept and discarded), with reasons for the discards in the *Trawl/Haul Log*. When there was time, the crew observer conducted a series of fish length and weight measurements that were recorded on a *Species Length Frequency Log*. They were asked to try to do these measurements on at least 25 fish during half the hauls.

Upon return to port, the captain completed the *Vessel and Trip Information Log*, which contains vessel and engine characteristics, as well as the onboard electronics inventory, the trip start and end times, ports and fish buyers, ice and fuel used, and fishing gear carried during each trip. The captains also completed a *Trawl Gear Characteristics Log* in which the nets are described in detail (including brands, materials and mesh sizes, doors, rigging components and sizes, ground gear, cod ends, fish outlets, transducers, etc.).

Figure 7. Data sampling gear that was issued to each fishing vessel at the start of a trip, included 2 ***Tidbit*** temperature sensors, ty-wrapped in protective nylon netting, a wet logbook, a 50 lb. scale, a packet of log sheets, and a length-frequency measuring board.

Data Transcription and Archiving: All the Trawl Survey data are archived in the SMAST Regional Fisheries Application Center (RFAC) Data Information Management System (DIMS). All the primary unprocessed data (Table 4) reside in the "Original" Data Layer of the RFAC Archive and are only accessible to the Project Data Manager (PDM; F. Bub in this case). The processed data is then used to populate the "Active' Data Layer of the RFAC DIMS Archive. The archive form for these Trawl fisheries data is a relational ***Oracle*** database that is composed of a suite of related tables (Figures 8 and 9). The following describes the processing that precedes entry into the Active database.

Table 4. Data files archived in the RFAC DIMS as "Original Data."

DATA LOG / FILE	SYMBOL	FILENAME	CONTENT
Environmental Data Position Log	P	Trawl###P.txt	Positions, time, weather, seas
Trawl/Haul Log (Fish)	F	Trawl###F.txt	Catch weights & disposition
Species Length Frequency Log	LF	Trawl###LF.txt	Length & count
Net Temperatures	A B C	Trawl###A.txt	Temperatures at 1 min intervals

= SMAST sequential trip number.

sheets. The heavy purple lines indicate the interrelationships that define the database.

The paper log data and information is converted to an electronic form and stored along with the ***Tidbit*** data on a desktop computer. *The Environmental Data Position Log* is entered in a ***Microsoft Excel*** spreadsheet (see Example 1 and Table 4). The data in the ***Excel*** spreadsheet are checked for proper positions, times, tow speeds, and other entry consistencies. A text file of this information is created for the RFAC archives and further analyses using ***Matlab*** routines.

COL	1	2	3	4	5	6	7	8	9	10
	TRIP	HAUL	S-T-H	NET	MON	DAY	YEAR	HR	MIN	DATE-TIME
	###	###	[1-2-3]	#	--	--	----	--	--	----------------
	001	001	1	1	06	03	2001	05	15	06/03/2001 05:15

COL	11	12	13	14	15	16	17	18	19	20
	LAT	N	LON	W	LAT N	LON W	TOW	TOW	WIRE	GEAR
	DEG	MIN	DEG	MIN	DEG	DEG	COURSE	SPEED	OUT	DEPTH
	41	31.97	68	52.15	41.5328	-68.8692	045	3.0	220	86.0

COL	21	22	23	24	25	26	27
	WATER	WAVE	WEATHER	WIND	WIND	HAUL	DELTA-T
	DEPTH	HEIGHT	CODE	DIR	SPEED	#	HOURS
	86.0	3.0	9	210	15.0	1	4.7

Example 1. Environmental Log Spreadsheet Record (P-files).

The *Trawl/Haul Log* fish catch data are entered on another ***Excel*** spreadsheet (Example 2). A text file of this data is also created for storage in the secure proprietary RFAC archive and data analyses. The *Species Length Frequency Log* data are also entered into an ***Excel*** spreadsheet and transferred to a text file (Example 3). The *Vessel and Trip Information Log* and *Trawl Gear Characteristics Log* entries are saved in still another ***Excel*** spreadsheet for insertion into the secure RFAC archive. (Only a few authorized users have access to these proprietary data).

COL	1	2	3	4	5	6	7	8	9	10
	TRIP	HAUL	TARGET	BOTTOM	SPECIES	KEPT	DISCARD	DISCARD	DRESS/	ACTUAL/
	###	###	SPECIES	TYPE	CODE	LBS	LBS	REASON	ROUND	EST. WT.
	000	001	1230	3	1220	00100	00000	00	D/R	A/E

Example 2. Fish Haul Log Spreadsheet Record (F-files).

COL	1	2	3	4	5	6
	TRIP	HAUL	SPECIES	WEIGHT	SIZE	COUNT
	###	###	CODE	LB-TOT	L-CM	AT-L
	001	001	0818	0041.0	052	01

Example 3. Fish Length-Frequency Data Record (LF-files).

The ***Tidbit*** temperature data are downloaded and translated from binary to text form using the ***Onset Corporation "Boxcar"*** software package (Example 4). These data are by the program and saved for archive and analyses.

COL	1	2	3	4	5	6	7
	MM	DD	YY	HH	MM	SS	DEGC
	06	01	01	11	57	01.0	22.89

Example 4. The Tidbit Temperature Record (A-, B- or C-file).

Data Interpretation, RFAC Archiving, and Preliminary Analyses: There is a need to correlate time and position with the on-bottom sections of each of the appropriate ***Tidbit*** temperature records. A ***Matlab*** routine is used to extract a correlated file of time, position, temperature, and bottom depth at 6-minute intervals. The resulting merged time, temperature, position, and depth file is illustrated in Example 5.

COL	1	2	3	4	5	6	7	8	9	10	11
	TRIP	HAUL	DD	MM	YY	HH	MM	Temp (C)	Lat-N	Lon-W	Depth (m)
	000	001	06	03	01	05	18	5.04	41.5342	-68.8674	156.2

Example 5. Trawl Time, Temperature, Position and Depth (T-files).

These archived bottom temperature records are processed to produce a product for assimilation into the SMAST RFAC operational AFMIS. The data, which can vary in depth by more than 100m on some trawls, are averaged into 10m depth bins before being used to initialize the bottom temperatures in the AFMIS Harvard Ocean Prediction System (HOPS) physical ocean model. The HOPS model products, including nowcasts and forecasts, are thus based in part on recent Trawl Survey measured bottom temperature data. Given the relationships between temperature and fish behavior, these model forecasts can provide important temperature environment to the fishermen. Examples of the use these data in AFMIS are available on the RFAC web site at
<**http://rfac.smast.umassd.edu**>.

Once processed and transitioned to the RFAC Active Data Archive (see Table 5), the secure RFAC DIMS Trawl Fisheries Archive can be queried via the web by authorized users. Such queries can subset the data into user-specified time and space windows. In the one “hard-wired” query example available at the moment, the resulting data array is composed of rows for each of the individual fish species in a haul (Example 6). Please contact Frank Bub (fbub@umassd.edu or 508-910-6307) for a demonstration or access.

```
COL 1      2      3  4  5    6  7    8         9       10         11
    TRIP  HAUL   MM DD YY   HH MM   delT-hr  LAT-N   LON-W       DEPTH-m
    003   001    12 03 00   16 51   1.5      41.3050  -69.6667   17

COL 12      13    14        15     16     17     18     19     20
    Target  Bot   Species   Kept   Disc   Disc   D-1    A-1    CPUE (lb/min)
    Spec.   Type  ####      lbs    lbs    Reas.  R-9    E-9    (COLS 15+16/8)
    1200    4     1200      0450   0000   00     01     09      5.0
```

Example 6. Merged Trawl Position, Temperature, Fish Data (PTF_A-files).

Specialized ***Matlab*** programs are used to manipulate these RFAC query-produced data files for further analysis. For example, a 119-column array of data for 35 different fish has been produced for B. Rothschild’s SYSTAT analyses. In this particular case, each row contains all the data from an individual haul (Example 6).

```
COL 1    2      3  4  5       6  7    8        9        10       11       12      13    14
  TRIP   HAUL   MM DD YYYY    HH MM   LEN HR   TEMP C   LAT N    LON W    DEP M TARG SP BTM
  ###    ###    -- -- ----    -- --   hour     deg C    deg      deg      btm-m  Code  Code
  000    001    01 07 2001    20 42   1.7      7.21     41.5129 -69.1150 136.0 0818   03

COL 15    16      17        18      19       20       21      22      23          →etc. for
  Spec.1  (0818=COD)---     Sp.2  (1220=WITCH FL)    Spec.3  (0120=MONK TAIL)   →35 species
  K_0818  D_0818  R_0818    K_1220  D_1220  R_1220   K_0120  D_0120  R_0120     →119 cols.
  00500   00000   00        00020   00400   24       00010   00000   00   . . . . . . . .
```

Example 7. Merged Trawl Position, Temperature, Fish Data (PTF_B-files).

In still another example, the length-frequency data are merged with position and temperature files to produce summaries of fish size distributions by species and haul. Example 8 shows the file format.

```
COL 1      2      3  4  5       6  7     8        9        10        11
    TRIP   HAUL   MM DD YYYY    HH MM    LEN HR   TEMP C   LAT N     LON W
    ###    ###    -- -- ----    --  --   hour     deg C    deg       deg
    003    007    12 05 2000    05 15    2.8      5.43     41.7900   -67.9050

COL 12      13        14       15          16
    DEP M   SPECIES   TOT WT   LENGTH CM   LEN COUNT
    btm-m   Code      Sample   Length      Frequency
    20      1200      0085     0037        0003
```

Example 8. Merged Trawl Position, Temperature and Length-Frequency Data (PLF_MERGE-files).

Table 5. Data files archived in the RFAC DIMS as "Active Layer Data."

DATA LOG / FILE	SYMBOL	FILENAME	CONTENT

Bottom Temperatures	T	Trawl###T.txt	Bottom Temperatures at 6 min intervals
Position, Environment and Fish (Long form)	PTF_L	Trawl###PTF_LONG.txt	Time, position, temperature, fish weights for 35 species by haul.
Position, Environment and Fish (Short form)	PTF_S	Trawl###PTF_SHORT.txt	Time, position, temperature, fish weights for all species by code.
Merged Position and Length-Frequency	PLF	Trawl###PLF_MERGE.txt	Time, position, species length & frequency count

= SMAST sequential trip number.

4. Categorizing Fishing Trip Data Quality

A qualitative scheme for categorizing different fishing trips has been developed. This scheme is based on the average number of fish species identified on a particular trip/haul. The assumption here is that the more different species that a fishing crew logs, the better the number and weight estimates will be (to be tested quantitatively during the upcoming phase of the Trawl Project).

The data quality category criteria for the BEST, SATISFACTORY and POOR categories in Table 6 are based on inspection of the data from the 3980 hauls made during the 111 trips considered here. In addition to the Table 6 criteria, the data were categorized as POOR, if a crew did not record any discards. The reference TECH category (a subset of BEST) refers to the average number species identified during the 19 trips in which the SMAST At-Sea Technicians participated.

Table 6. Fishing Trip Data Quality Categorization Chart

Data Quality Category	Number of Fish/Haul	Number of Fish/Trip	Number Trips (% of total)	Number Hauls (% of total)
BEST	> 8	> 23	32 (29%)	1046 (26%)
SATISFACTORY	> 4	> 10	58 (52%)	2203 (55%)
POOR	< 4	< 10	21 (19%)	731 (19%)
TECH	9.6	26.6	19 (17%)	578 (15%)

These results show that approximately 81% of the data can be categorized as SATISFACTORY quality or better. The Trawl Project data reported on here falls into the combined BEST+SATISFACTORY quality category.

D. Trawler Survey Project: Results

F. L. Bub & W. S. Brown (3/21/2006)

The initial results of the Trawler Survey Project data are presented in this section. Only the data categorized as SATISFACTORY and BEST (the best 81%) have been considered here. Figures referred to in this section are in a separate file.

1. Monthly Fish Data Summaries

Summaries are produced for the 10 months of actual project survey time between December 2000 (which includes parts of trips started in November 2000) and September 2001 (which includes some data collected in early October 2001). Some minor double-counting occurs in the monthly summaries because a few trips span more than one month, but the overall project summaries are accurate.

The focus of this report is on the "Top 10" species, which are receiving the most attention in the ongoing Rothschild analyses. This is definitely a **codfish** fishery. However the fishermen bring a multi-species catch to market. Note that, while all of several species of **skate** have been aggregated into one category in Table 7, the actual data are listed by species. Also the **monkfish** data are the sum of TAIL plus WHOLE numbers.

Key to Table 7 and Comments. In addition to monthly statistics, the normalized WEIGHT PER HAUL and average CPUE are presented. The latter make it easier to make inter-month comparisons. The definitions of terms used in Table 7 are as follows:

1. **HAULS RECORDED** – Number of hauls during which a particular species was inventoried.
2. **CPUE** – Monthly average catch of the species per unit effort(in pounds/minute) for individual hauls. Note that the CPUE for **skate** is weighted according to separate species weight.
3. **HAULS % OF TOTAL** and **POUNDS/HAUL** – Indicate frequency and amount of the species showing up in a particular month. These also suggest the seasonal changes in target species.
4. **RANK -** Position the ten species based on the ratio of (**HAULS % OF TOTAL)/ (POUNDS/HAUL)**.

The data for June and July 2001 should be viewed with the knowledge that relatively less fishing was done during those months and that fishing seemed targeted on specific species. This might explain the relatively large increases for **codfish** and **haddock** and decrease in **monkfish** between June and July.

Summary: Codfish are logged during 84% of the hauls (ranked #1) with an average of about 224 pounds decked during each haul (ranked #4). This results in an average of about 8700 pounds of codfish during an average 39-haul Trawler Survey Project trip. The **codfish** CPUE and weight/haul reach a peak in March. By far, the greatest weight/haul belongs to the collective **skate species** (559 lb/haul). The second most popular species by percent of entries is **monkfish** (82%) and second by weight/haul is **yellowtail flounder** (302 lb/haul). Third by percent of entries is the **skate species** (75%) and third by weight/haul is **winter flounder** (274 lb/haul). Fourth place by percentage of entries is **witch flounder** (53%) and fourth by weight/haul is **codfish** (224 lb/haul).

The fifth ranking by entries is **lobster** (52%) and by weight/haul fifth is **monkfish** (221 lb/haul). The sixth by entries is **plaice flounder** (50%) and sixth by weight/haul is **haddock** (195 lb/haul). In the seventh place by entries is **haddock** (45%) and by weight/haul is **plaice** (124 lb/haul). The eighth ranking by entries is **winter flounder** (36%) and by weight/haul eighth is **witch flounder** (98 lb/haul). In ninth place by entries is **yellowtail flounder** (33%) and by weight/haul it is **pollock** (89 lb/haul). Tenth by number of entries is **pollock** (21%) while tenth by weight/haul is **lobster** (48 lb/haul).

Seasonal trends: These are a bit hard to discern from this 10-month data set, but the following are some general observations concerning the "Top 10" species:

The best times to fish for **codfish** and **haddock** are early spring and mid-summer. **Haddock** are also successfully targeted during mid-winter. **Monkfish** are most often caught during late summer although the highest weight/haul numbers occurred during spring. **Yellowtail flounder** is a winter fishery, with varying levels of success that peak in winter and spring. The **witch flounder** fishery seems relatively constant throughout the year. There is a rise in **lobster** catch and CPUE in later summer. **Winter flounder** and **plaice flounder** are most often caught during the summer months. **Pollock** fishing is most successful in winter.

A More Detailed Discussion of Individuals Species: In terms of both CPUE and PERCENT OF HAULS, fishing for **codfish** is most successful in the late winter to spring (March-April). The largest CPUE and WEIGHT PER HAUL for **codfish** both occur during July. A second large CPUE peak during March-April is separated from the summer peaks by low numbers in May, when the area north of Georges Bank is closed. The PERCENT OF HAULS in which **codfish** are recorded average about 84% and are relatively high throughout the year. This number also reaches a peak in March.

Witch flounder (greysole) CPUE and PERCENT OF HAULS remain relatively constant throughout the year. All measures are lowest during December-January, with peaks during February, May, and August.

M**onkfish** are recorded on almost every haul during February-March and again during late summer (August-September). CPUEs are lowest in early winter (December-January) and greatest in late spring (March-April and then June). The July dip seems anomalous and may be because the limited number of project vessels that recorded data during July did not target **monkfish**. WEIGHT PER HAUL is greatest during spring with a maximum in June.

Plaice flounder (sea dab) numbers show a two-fold increase between winter and summer in both CPUE and WEIGHT PER HAUL (both peak in August). In contrast, the PERCENT OF HAULS is greatest in April and a minimum during July.

The **lobster** CPUE, PERCENT OF HAULS and WEIGHT PER HAUL remain relatively constant until late summer (August-September) when the WEIGHT PER HAUL rises dramatically.

Skate CPUE and WEIGHT PER HAUL vary widely, but both are very large during July with secondary peaks in January. The July peak may also reflect a sampling bias as large hauls of **skate** were taken on the top of Georges Bank, the primary fishing ground during that month. About 77% of **skate** are discarded. We note that all scaled values for **skate** are 3-5 times larger than those for other species.

Both CPUE and WEIGHT PER HAUL data indicate that fishing for **haddock** is most successful in the mid- to late winter (January and March). These are in dramatic contrast with much lower measures in spring (April through June) and late summer to fall (August-September-December). The large peaks during July may reflect a data collection bias, although there were some very large individual catches recorded in the vicinity of CAI that month.

The CPUEs for **yellowtail flounder** also vary widely throughout the year, with large peaks in December, May and August. While found in an average of 30% of the hauls, the species has high WEIGHT PER HAUL values when they are most often caught during December and again during May.

Pollock CPUE and WEIGHT PER HAUL are both greatest during the winter months (December-February). **Pollock** are caught less often during the summer months.

Winter flounder (channel or Georges flounder) CPUEs and WEIGHT PER HAUL are highest during the summer months (June-July) with this species recorded most often during June. All measures reach a minimum during January and February. Could this species be misnamed in the Gulf of Maine? The total **winter flounder** weights recorded during the summer months far exceed those of winter.

2. Trawl Fisheries Catch Distributions and the Environment.

The discussion of these results is based on Figures B.1- B.10 and Figures C.1- C.10.

Key to CPUE Distribution Figures B.1. to B.10

CPUE values (in pounds/minute) for the top ten species are located at the start of each haul. Isolated black dots locate hauls where none of the species was logged. The diameter and color scale for the CPUE circles appears below each plot in a graph that also shows the distribution of CPUEs-- which are universally Rayleigh (Chi-Squared) in form. Note that the maximums of the lower graphs are scaled to the species maximum CPUE values (the larger blue circles). The permanent gear closure areas (magenta) are from west to east Nantucket Lightship (CAN), Closed Area I (CAI), and Closed Area II (CAII). The USGS bottom bathymetry is defined by major (dark blue) contours at 100, 200, 500, 1000, 2000, 3000, and 4000m and other contours (light blue) at 5, 10, 15, 20, 25, 30, 35, 50, 75, 150, 250, 300, 400, 750, 1500, and 2500m respectively.

Key to CPUE/Haul Count vs Environment Histograms Figures C.1. to C.10.

The panels on the left are histograms of **CPUE** (pounds/minute) and the panels on the right are **Number of Hauls (HAUL COUNT)** versus the following environmental variables from top to bottom:

- ***Tidbit*** **Bottom Water Temperature** (ΔT = 1°C)
- **Logged Bottom Depth** (ΔD = 10m)
- **Hour of the Day** (Δt = 1 hour)
- **Month of the Year** (Δm = 1 month)
- **Logged Bottom Type**
  (1 = rocky ledge, 2 = rocky edge, 3 = sandy, 4 = mud, 5 = other)

Note that the vertical scales on each of the panels are adjusted to the particular data maxima and thus are not visually comparable.

Table 8 summarizes the general results of the visual relationships between species catch and depth, bottom temperature and bottom type preferences. A more detailed discussion follows.

Table 8. Summary Table of Environmental Preferences for the "Top 10" Species.

		DEPTH			TEMPERATURE			BOTTOM TYPE	
	SPECIES	RANGE (m)	MOST ENTRIES	MAXIMUM CPUE	RANGE (°C)	MOST ENTRIES	MAXIMUM CPUE	MOST ENTRIES	MAXIMUM CPUE
1	Codfish	50-70, 150-190	70 160	70 270	5-7	5	4	Mud (4)	Sandy (3)
2	Witch Flounder	160-190	180	120	5-7	7	5	Mud (4)	Mud (4)
3	Monkfish	160-190	180	140 220	5-7	7	4	Mud (4)	Mud (4)
4	Plaice Flounder	160-190	180	180 130	5-7	5	6	Mud (4)	Mud (4)
5	Lobster	180-190 40-70	190 50	50 200	5-7	7	8	Mud (4)	Rocky Edge(2)
6	Skate (all species)	50-70 150-160	70 150	30,50 60,130	5-7	5	4	Mud (4)	Sandy (3)
7	Haddock	150-190	190 160	110 100	5-7	7	4	Mud (4)	Sandy (3)
8	Yellowtail Flounder	50-80	70	80	5-6	5	6	Sandy (3)	Rocky Edge(2)
9	Pollock	160-190	190	170-180 210	5-7	7	7	Mud (4)	Other (5)
10	Winter Flounder	50-70	50	30	5	5	12	Sandy (3)	Other (5)

Discussion: Codfish are caught throughout the Georges Bank fishing region, except for a few hauls in Wilkinson Basin. They are most often found at either 50-70m or 150-190m depths (this bimodal structure may be a reflection of fishing practices and the local bathymetry rather than actual codfish distributions). The greatest CPUEs are either in the 40-80m depth range (the maximum CPUE is at 70m) or 250-270m (maximum at 270m). **Codfish** are most often found in the 5-7°C water temperature range with a peak number of hauls inventoried at 5°C. Highest CPUEs are at 4°C with a second high CPUE at 9°C. **Codfish** are most often fished on a muddy bottom (#4) while the highest CPUEs are found over a sandy bottom (#3).

Note that these results suggest approaches to improve **codfish** fishing efficiency. While the fishermen seem to prefer to trawl at depths of 150-190m, the CPUEs at these depths are less than in either the 40-70m or 190-200m depth ranges. Similarly, while there is more fishing over a muddy bottom, there are higher CPUEs when **codfish** are caught over sandy bottoms.

Witch flounder are normally caught in mid-depth Gulf of Maine waters from 150 to 190m deep, with the maximum number of hauls logged at 180m. High CPUEs range from 110-140m depths (maximum 120m - the 30 and 50m peaks are recorded on a small number of hauls). The greatest CPUEs are found in the deep ridge south of Wilkinson Basin and east of Cape Cod (larger blue circles - Figure B.2.). **Witch flounder** are most often found in the 5-7°C water temperature range with a peak count at 7°C. Higher CPUEs are at 5-7°C with a maximum CPUE at 5°C. This species is usually fished on muddy bottoms (#4) and the CPUE is greatest on that bottom type.

Monkfish are also deep water fish found at depths of 160-190m (and most often at 180m). There are some shallow catch exceptions on Georges Bank west of CAI and southwest of CAII. The larger CPUEs range widely across depths of 140-230m with a maximum CPUE at 220-230m in Franklin Basin north of CAI. Temperature preference is 5-7°C with higher CPUEs at 5°C and 7-8°C. The latter also represents the Franklin Basin area. **Monkfish** are most often found on muddy bottoms (#4) and this is also the bottom type with the greatest CPUE.

American plaice flounder (sea dabs) are found in waters between 160-190m, with the most catch entries at 180m. Higher CPUEs cover a wide range of depths from 100-170m with a maximum at 180m and a second peak at 130m. With a few exceptions, **plaice** are seldom caught on Georges Bank. Highest CPUEs are found on the slope west of CAII (reflecting the 130m peak) and on the northeast edge of CAI (the 180m peak). Temperature preference is 5-7°C with higher CPUEs in the same range (maximum CPUE at 6°C - the 9°C bar is an anomaly). This species is most often found on a muddy bottom (#4) and this is also the bottom type with the highest CPUE.

American lobsters are generally caught in either the shallower 40-70m or deeper 180-190m depth ranges. As with **codfish**, this may be more a reflection of fishing practices than natural distribution. Preferred depth seems to be 190m, followed by 50m. The greatest CPUEs are in the 50-60m range, with a second area of similar CPUEs deeper than 200m. The higher CPUEs in the shallow depths represent a series of very successful hauls on Georges Bank near Cultivator Shoals (light blue circles - Figure B.5.). Most relatively high CPUEs are on the north slope of Georges Bank (yellow-orange band). Temperature preference range is 5-7°C. There are some very high CPUEs when the water is very warm at 10-12°C. **Lobsters** are most often caught on a mud bottom (#4) although higher CPUEs are found on a rocky edge (#2) or sandy bottom (#3).

Skate species catches are recorded everywhere except for a few hauls in southern Wilkinson Basin. As discussed above, the bimodal structure of the depths at which they are found (50-80m and 150-160m) may reflect fishing practices more than actual **skate** distributions. Highest CPUEs are in the shallow 30-60m depth range. Figure B.6 shows these high CPUES (blue) occur on Georges Bank, particularly on the western boundary of CAII and along the north edge. Another high CPUE region follows the eastern slope of Nantucket Shoals. Temperature preferences are 5-7°C (maximum entries at 5°C). Highest CPUEs are in the warmer ranges (13-15°C), although the 4°C peak more likely represents normal conditions. **Skate** are most often caught on muddy (#4) or sandy (#3) bottoms. Highest CPUEs are over rocky ledge (#1), rocky edge (#2) and sandy (#3) bottoms.

Haddock are mostly caught in the deeper 150-190m depths (the most catch entries are at 190m followed by 160m). The highest CPUEs are concentrated at the 100-110m depths, where some very large hauls occurred north of CAI (larger blue circles). A second high CPUE area is concentrated west of CAII on the northern edge of Georges Bank at a depth of about 110m. We note that, as with **codfish**, the higher CPUE ranges are at the "less fished" depths. Temperature preferences for **haddock** are 5-7°C (maximum catches recorded at 5°C). The highest CPUE bar when the bottom temperature is 4°C is due to an isolated haul, with 6°C more likely the norm. **Haddock** are most often caught over a muddy bottom (#4) while CPUEs are greatest over a sandy bottom (#3).

Yellowtail flounder are caught in the relatively shallow water of Georges Bank at depths of 50-80m (maximum catch entries at 70m). Higher CPUEs span 60-100m with a CPUE peak at 80m. As expected, the black dots on Figure B.8. show few catches in the Gulf of Maine deeper than 100m. A very successful **yellowtail** fishery lies on the north edge of Georges Bank at the western boundary of CAII at about 80m. There are also some high CPUEs at the southwest corner of CAII and west of CAI. Preferred temperatures range is 5-9°C (maximum 5°C). Highest CPUEs are 6-9°C (maximum at 6°C). **Yellowtail** are most often caught on a sandy bottom (#3) while the greatest CPUEs are over a rocky edge (#2) and sandy bottom (#3).

Most **pollock** are caught in waters deeper than 150m (maximum number of catch entries at 190m). The highest CPUEs are at depths of 170-180m, with a concentration of very high CPUEs noted in Franklin Basin north of CAI (blue circles - Figure B.9.). Preferred temperatures are 5-7°C (maximum 7°C). The highest CPUEs are also 5-7°C with the greatest CPUE at the deeper water 7°C. **Pollock** are most often caught over a muddy bottom (#4) although the higher CPUEs occur over what have been recorded as "other" bottoms (#5).

Winter flounder are found in the shallow waters of Georges Bank between 40-70m (maximum number of entries at 50m). Regions west of CAI and the eastern slope of Nantucket Shoals are popular fishing grounds for this species. The highest CPUEs are at 30 and 50m depths (the 130m peak from the northeast edge of CAI is an anomaly). Temperature preference is 5°C. High CPUEs span a wide temperature range of 9-15°C with a maximum at a very warm 12°C. This reflects the summertime fisheries for **winter flounder** in the warm, shallow waters of the area. These fish are most often caught over a sandy bottom (#3) while the greatest CPUEs are noted over a rocky edge (#2) or the unspecified "other" bottom type (#5).

3. Monthly Bottom Temperature Distributions

The ***Tidbit*** bottom temperature data (also see the **Methods** discussion) have been aggregated by month into 15km squares (0.14 degrees latitude or 8.1nm) and the distributions are presented in Figures D.1. through D.11.

> **Key to Figures D.1. - D.11.**
>
> The monthly bottom temperatures generally range from 4 to 10°C, with some summer bottom temperatures greater than 10°C (red, also see Table 9). The permanent gear closure areas (magenta) are from west to east Nantucket Lightship (CAN), Closed Area I (CAI), and Closed Area II (CAII). The USGS bottom bathymetry is defined by major (dark blue) contours at 100, 200, 500, 1000, 2000, 3000, and 4000m and other contours (light blue) at 5, 10, 15, 20, 25, 30, 35, 50, 75, 150, 250, 300, 400, 750, 1500, and 2500m respectively.

The December 2000 to October 2001 average bottom temperatures across the region are shown in Figure D.1. Discussions of the monthly distributions follow.

Monthly Bottom Temperature Distributions: In December 2000, waters on Georges Bank are relatively warm at 8.5°C west of CAI and 9°C southwest of CAII. The waters of the Great South Channel are also relatively warm at 7.5-8°C, consistent with the climatologies plotted in Figures E.2 to E.13.

In January 2001, we observe cooling on Georges Bank to 5.5-6°C. The Great South Channel area north of CAI also cools to 7°C. The western

Georges Basin area remains relatively warm compared to shallower regions at 8°C.

By February 2001, the top of Georges Bank is 5.5°C or colder. The Great South Channel west of CAI and the Nantucket Shoals are also cold at 4.5°C. Western Georges Basin remains at 7.5-8°C, as do the deeper waters of Wilkinson Basin.

In March 2001, bottom waters on Georges Bank are at a minimum of 4.5°C or less. The waters east of Nantucket Shoals are also this cold. In the deeper regions north of CAI, waters are also a cool 5.5-6°C. Georges Basin has also cooled a bit to 7.5-8°C.

The April 2001 bottom temperature plot shows the coldest temperatures for the year. This is consistent with the climatology shown on Figures E.1 to E.12. Nantucket Shoals and Georges Bank are both less than 4°C, as is the deeper area north of CAI. Deep waters of western Georges Basin remain warm at 7.5-8°C.

In May 2001, the Georges Bank region east of CAI has warmed to 8.5-9°C. The north edge west of CAII remains relatively cool at 5.5-6°C. The cool spot (5-5.5°C) on Franklin Swell contrasts with the warmer Wilkinson Basin waters at 8°C. The western Georges Basin remain warm at 8°C.

During June 2001, the area southwest of CAII is still quite cool at 4-4.5°C. Another cool spot continues on the north edge of Georges Bank at 5-6°C. The shallower regions of Georges Bank continue to warm to as high as 9.5°C. The Great South Channel north of CAI stay cool at 4-5°C. Georges Basin stays at 8°C.

By July 2001, some areas of Georges Bank exceed 10°C. There are also some 9-10°C bottom temperatures on Nantucket Shoals. The cool 4.5-5°C regions on the southern part of Georges Bank and west of CAII seem anomalous. The cooler region along the north slope west of CAII may reflect fishing north of the tidal front that sets up in that area during summer. Georges Basin is still at 8°C.

By August, the cap of Georges Bank and Nantucket Shoals are warmer than 10°C (with temperatures as high as 15°C observed). This is in sharp contrast to the 4-5°C bottom temperatures in the central Bank west of CAII. The north edge of Georges Bank is 6-7°C, indicating a 3-4°C gradient across the tidal front in that area. There is little change in Georges Basin. Upwelling east of Cape Cod keeps bottom temperatures close to 5°C.

The September 2001 bottom temperatures look very similar to August, except that the tidal front is not as strong as north slope temperatures rise to 7°C. Some cooling is evident in Franklin Basin where the previous month's bottom temperatures of 7.5°C fall to 6.5°C.

4. Time Variability of Bottom Temperature at Specified Locations

Time series of Trawler Survey Project monthly-average temperatures have been developed at the twelve locations containing the largest number of monthly ***Tidbit*** bottom temperature data entries (Figure E.1). These observed bottom temperature data are compared with a regional climatological bottom temperature data at the same locations in Figures E.2. through E.13. This 1970-1990 climatology was developed by F. Bub, using temperature-salinity profiles in an archive developed by the Bedford Institute of Oceanography as part of the Atlantic Fisheries Adjustment Program (AFAP).

A summary of the Trawl Project average bottom temperatures at the twelve selected locations appears in Table 9. Descriptions of the bottom temperature time series at each of these locations follow.

Table 9. Monthly average ***Tidbit*** bottom temperatures at the indicated twelve southern Gulf of Maine and Georges Bank locations (see Figure E.1).

POINT	A	B	C	D	E	F	G	H	I	J	K	L
LATITUDE N LONGITUDE W	41.7 69.6	41.5 69.3	41.0 69.2	42.1 69.1	41.5 68.9	41.9 68.8	41.7 68.4	42.0 68.0	42.2 67.8	42.0 67.8	42.2 67.5	41.0 67.6
Estimated Depth (m)	112	108	66	180	137	153	153	210	228	74	217	66
Dec 00	--	8.6	--	--	7.9	--	7.9	--	--	--	--	--
Jan 01	--	6.4	--	--	6.8	7.4	7.8	7.9	8.3	7.1	8.3	6.3
Feb 01	5.2	5.9	--	--	6.2	--	7.1	7.9	7.4	--	7.7	--
Mar 01	5.3	5.0	5.9	--	5.7	5.8	7.4	7.9	8.0	5.4	7.2	5.0
Apr 01	--	--	--	7.8	5.3	5.4	6.2	7.6	7.8	5.8	7.2	5.0
May 01	--	--	--	6.0	--	--	9.9	7.4	8.2	6.0	7.6	--
Jun 01	--	--	--	--	5.0	5.7	7.1	--	--	6.1	7.5	--
Jul 01	--	5.0	10.2	--	5.1	--	6.4	--	--	15.2	--	--
Aug 01	5.2	5.1	8.9	--	5.4	--	6.6	7.4	--	10.6	7.6	--
Sep 01	5.5	5.9	10.1	6.8	5.7	6.4	7.0	7.1	7.7	12.2	7.5	--
AVERAGES	5.39	6.06	8.96	6.16	6.07	5.96	6.88	7.42	7.84	8.54	7.55	5.33

"--" indicates no data were collected in that 15km square area.

(A) Northeastern Nantucket Shoals east of Cape Cod: at a depth of 112m, the measured bottom temperatures near 5.4°C changes little over the year. This reflects the summertime upwelling, common here, that keeps this area cool throughout the year. The observed data agree well with the area's climatology (Figure E.2.).

(B) Eastern slope of Nantucket Shoals: At 108m depth, there is cooling after a December high of 8.6°C to a March low of 5.0°C. The bottom temperatures remain less than 6°C through the summer, rising rapidly to about 13°C from September to October. The observations we collected are also consistent with the climatology.

(C) Southeastern Nantucket Shoals in the Great South Channel: At 66m depth, the cool 5.9°C waters of March warm to 10.2°C by July. Climatology suggests these waters will get as warm as 15°C by October. While observations are consistent with the climatological cycle (Figure E.4.) we note that the actual winter temperatures are about 2°C warmer than expected and the late summer (September 2001) waters are nearly 4°C cooler than expected. This moderation of the annual cycle does not show up at other points we have examined.

(D) Southern Wilkinson Basin, north Franklin Swell: At 180m depth, the bottom temperature falls from 7.8°C in April to 6.0°C in May. It then rises to 6.8°C by September 2001. The April temperature is about 3°C warmer than expected, while the other observations are consistent with climatology.

This April warming may be a clue to water mass processes in the Gulf of Maine. We could make a case for tracking a parcel of 8°C water back in time as it flows westward through points K, I, and H during January, February, and March, respectively (Figure E.1). A pulse of warm Atlantic Slope Water may have entered through the Northeast Channel and moved slowly toward Wilkinson Basin. This is speculative without concurrent salinity observations (the Slope Water would be distinctively saltier than the "normal" Gulf of Maine waters).

(E) North central Great South Channel: At 137m, we have a nearly complete set of observations that show the bottom waters cooling from a December high of 7.9°C to a June minimum of 5.0°C. This is very consistent with the climatology.

We note that at this mid-Gulf depth, bottom temperature changes seem to lag those at the surface by 3-4 months. Thus, the ocean surface minimum temperature occurs during February while at 140m, we see a minimum during May-June. On the other hand, the surface water will reach a maximum temperature in September, while the bottom water at this depth reaches its maximum in December. A comparison between Figures E.6. (point E) and E.11. (point J) supports this observation.

(F) South Franklin Swell: At 153m depth, measured bottom temperatures cool from a 7.9°C maximum in January and remain relatively constant at 5.7°C to 5.4°C through the summer. The observations are within 1°C of the climatological values.

(G) Central north edge of Georges Bank north slope: At a depth of 153m, the 7.9°C water of December cools slowly to a minimum of 6.2°C in April and remain in the 6.4-7.1°C range through the summer (except for May). This trend agrees with climatology. The May 2001 temperature of 9.9°C is likely anomalous as it is based on only 3 pieces of data, an order of magnitude less than the number used for most other points.

(H) Western Georges Basin: At a depth of 210m, the bottom water stays at a relatively constant temperature of 7.4-7.9°C. This steady temperature at depths greater than 200m is consistent with climatology.

(I) Central Georges Basin: At a depth of 228m, the observed monthly pattern of nearly constant temperatures between 7.4°C and 8.2°C also agrees well with climatology. Note the January peak, which might be a pulse of Atlantic Slope Water noted earlier.

(J) Central Georges Bank north slope: At 74m depth, there is a cooling trend from 7.1°C in January to a minimum of 5.4°C in March, followed by a warming to 12.2°C in September. This follows the climatological cycle which ranges from a minimum of 3°C in January to a maximum of 14°C in October. The 15.2°C observation during July 2001 appears anomalous when compared with a climatological value of 7.9°C. However, there are a number of other 15°C observations in the vicinity at this time, so this high bottom temperature is possible-- particularly if the north slope tidal front remained north of this point.

(K) Georges Basin west of CAII: At a depth of 217m, we again see a relatively constant bottom temperature of 7.4-8.3°C, as suggested by climatology. Once more, the relatively warm 8.3°C measurement during January may be associated with the westward pulse of Atlantic Slope Water noted earlier in the discussion of point E.

(L) Georges Bank southwest of CAII: At a depth of 66m, only three winter months are measured. The data reflect the wintertime cooling as climatology suggests. Temperatures in this area should exceed 13°C by September.

Appendix A. Participating Vessels

The 20 New Bedford TSF groundfish trawling vessels listed below collected data during the combined 721 fishing days on 119 separate trips.

	Vessel	Captain	Trips	Fishing Days	Total Hauls
(1)	Seel	T. Lees	8	48	381
(2)	Isabel S	J. Hatfield	11	60	379
(3)	Maria Angela	C. Braz	1	7	25
(4)	Victory	M. Marquinhos	5	18	110
(5)	Curlew II	W. Sherman	11	60	435
(6)	Buzzards Bay	A. Sherman	10	51	367
(7)	Tropico	T. Lees	8	58	413
(8)	Fisherman	P. Cudra	9	63	355
(9)	Humbak	S. Adamaski	8	62	268
(10)	Inheritance	J. Rogers	10	51	325
(11)	Voyager	F. Marques	6	41	251
(12)	Lady of Grace	J. Santos	4	32	157
(13)	São Marcos II	A. Sao Marcos	7	52	301
(14)	Mischief	A. Smith	2	7	34
(15)	Resolute	A. Sherman	4	24	160
(16)	São Paulo	T. Borges	6	47	254
(17)	T Luis	T. Santos	2	6	89
(18)	Blue Seas	A. Pereira	1	6	43
(19)	United States	A. Crevo	1	6	50
(20)	Glenna & Jacob	R. Kohl	3	10	70
	Totals		119	721	4,508

Appendix B: Project Log Entries.

Summary of Log Sheet entries for data collected as part of the High-Resolution Industry-Conducted Fishery Resource Survey.

1. Vessel and Fishing Gear Characteristics Summary Sheet

- Vessel name and number
- Construction, length, tonnage, hold capacity, year built
- Refrigeration and fish processing capabilities
- Engine(s) age, horsepower, fuel
- Electronics in wheelhouse (navigation, communication, sonar, etc)
- Fishing gear (net) characteristics (for each set)
- Material, sizes (lengths, openings, cables, meshes, doors)
- Net elements (codends, headropes, ground gear)
- Electronics on fishing gear (transducer, depth, temperature)

2 Vessel and Trip Information Log

- Vessel name and number
- Target species
- Sail and return dates and times
- Landed port and dealer
- Crew size, captain's experience
- Gear (nets) on board and used
- Fuel and ice used
- Time lost to fishing and reasons

3. Trawl Haul Log

- Vessel name and number, observer ID
- Haul number (sequential)
- Haul start and end
- Date, time, latitude (degrees and minutes to hundredths), longitude
- Gear used (and mounted electronics)
- Gear depth, condition
- Water temperature
- Target species
- Bottom depth and type
- Weather (type code, wind direction & speed, wave height)
- Distribution of species caught in the haul
- Name, weight (kept and discarded), discard reason
- Weight type (dressed, round,actual estimated).

4. Species Length Frequency / Weight Log

- Vessel name and number, haul date and sequential number
- Species name
- Disposition (kept / discarded)
- Sample weight (group total)
- Length – frequency count (~25 fish – distribution of each length to nearest cm in group)
- Sub-sample of individual fish weights versus lengths (not doing).

5. Environmental Data Log

- Vessel name and cruise information
- Haul number, net number
- Whether entry is the Start – Turn – End of the haul
- Date and time of position entry
- Position (latitude and longitude in degrees and minutes to hundredths)
- Course and speed during haul
- Water depth, wire out and gear depth.